

Pacific Marine Environmental Laboratory

Please provide a brief history and mission of your laboratory/center.

What does the Pacific Marine Environmental Laboratory do for the nation?

The Pacific Marine Environmental Laboratory (PMEL) carries out interdisciplinary scientific investigations in oceanography and atmospheric science. Current PMEL programs focus on deep ocean observations in support of long-term monitoring and prediction of the ocean environment on time scales from hours to decades. Studies are conducted to improve our understanding of the complex physical and geochemical processes operating in the world oceans, to define the forcing functions and the processes driving ocean circulation and the global climate system, and to improve environmental forecasting capabilities and other supporting services for marine commerce and fisheries. **Employing state-of-the-art buoy and satellite technologies, PMEL has developed the capability to collect data from anywhere in the global oceans from any depth and transmit these data in real time for display and distribution over the internet.**

Results from PMEL research activities contribute to NOAA's mission goals #1: Protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management, #2: understand climate variability and change to enhance society's ability to plan and respond, and #3: serve society's needs for weather and water information. PMEL provides sound, state of the art research that underpins NOAA's environmental assessment, prediction, and ecosystem management missions and contributes to the development of an integrated global environmental observation and data management system.

A Brief History

PMEL was formed in 1973 from the National Ocean Service (NOS) Pacific Oceanographic Laboratory and the Environmental Research Laboratory Institute for Oceanography. Initial emphasis of the lab was on water quality and environmental impact issues in Puget Sound, off the Oregon and Washington coasts, in the Gulf of Alaska and the Bering Sea, and in the equatorial Pacific Ocean. In the early 1980's, the Puget Sound work evolved into Hazardous Materials Response and was transferred to NOS, and programs to conduct research on seafloor hydrothermal vents, fisheries oceanography, (jointly with the National Marine Fisheries Service (NMFS) Alaska Fisheries Science Center), and El Nino research were initiated. Tsunami research, which had been a charter program of the Laboratory, increased in prominence in the mid-1990's by the establishment of the National Tsunami Hazard Mitigation Program. Research programs to provide a better understanding of the ocean's role in global climate change developed during the 1990's along with the Office of Global Programs. Some particular laboratory highlights:

1973	PMEL founded
1976	First equatorial mooring deployed
1979	Begin equatorial climate studies

1983	Begin VENTS and FOCI programs; end Puget Sound research, transfer HazMat responsibility to NOS; major El Nino event
1986	First megaplume discovered (plume of chemical- and heat-enriched water produced by an underwater volcanic eruption)
1992	First FOCI Pollock recruitment prediction
1993	First acoustic detection of deep sea volcanic eruption
1994	TOGA-TAO Array completed – largest oceanographic observation system in the world
1997	First prediction of major El Nino using TAO data Begin National Tsunami Hazard Mitigation Program
1998	Established NeMO as the world's first deep ocean volcano observatory
2001	Tsunami detection buoy array completed; begin Ocean Exploration program
2002	Second prediction of El Nino using TAO data
2003	Detection and real-time reporting of a small tsunami in the open ocean leads to early cancellation of tsunami warning, avoiding evacuation of Hawaii coastal areas; begin CO2 repeat hydrographic sections and PMEL's ARGO float programs; transfer responsibility for tsunami detection buoys to the National Weather Service.
2004	Identification of North Pacific climate state to complement the Pacific Decadal Oscillator that explains present climate condition.

Please provide a listing of major customers of the laboratory/center, with a one sentence description of what is being done for them.

Climate: NOAA/NWS, and international meteorological agencies
CLIVAR, IPCC, GOOS, and GCOS
Climate researchers worldwide

PMEL provides research quality data in near real-time for climate research and climate prediction models; PMEL researchers conduct climate investigations pertaining to ENSO, oceanic CO2 inventories, and the impact of aerosols on the atmosphere and climate. PMEL contributes data from TAO/TRITON, ARGO, and global repeat hydrographic surveys to national and international programs.

Fisheries- NOAA/NMFS/North Pacific Fishery Management Council
Oceanography NOAA/NOS/GLOBEC
Coordinated North Pacific Marine Research Board
Investigations Exxon Valdez Oil Spill Trust
(FOCI) Alaska fishing industry
Coastal communities of Alaska

PMEL/FOCI supports Alaska and North Pacific fisheries interests by conducting research on the impact of the marine environment on the North Pacific and Bering Sea ecosystems, and in turn the effects of the ecosystem on fish populations. FOCI produces

an annual forecast of the population abundance of the commercially-important North Pacific pollock fishery, which is used as input to the North Pacific Fishery Management Council's annual catch allocations.

VENTS: National Science Foundation (RIDGE and NEPTUNE programs)
University of Washington, Oregon State University, Woods Hole,
and University of Victoria (British Columbia)
NOAA/NOS/Census of Marine Life
NOAA/NMFS/Northwest Fisheries Science Center

PMEL VENTS scientists collaborate with universities to improve our understanding of the worldwide oceanic implications of the impacts of seafloor volcanism. VENTS is also investigating the subseafloor biosphere that may yield promising new life forms important to the pharmaceutical and biotechnology industries. Acoustic monitoring of undersea volcanoes pioneered by VENTS scientists has applications to NOAA's Marine Mammal programs.

Tsunami: NOAA/NWS/Tsunami Warning Centers
Coastal communities of Alaska, California, Hawaii, Oregon, and
Washington
International coastal communities exposed to tsunami hazards

PMEL has improved tsunami warnings through the development of deepwater tsunami detection capabilities (tsunameters) and continues to improve basin-scale propagation and inundation models. Using models and deep ocean data, scientists have developed an experimental tsunami forecast methodology that is being infused into NWS Operations. PMEL coordinates the five states to provide consistent tsunami inundation maps to coastal communities that aid in mitigation and emergency preparedness activities.

Information Technology: Integrated Ocean Observing System
Other NOAA Line Offices
Users of ocean and atmospheric datasets worldwide

PMEL data integration activities are key in the development of the IOOS data management system and in providing data management and manipulation techniques to researchers and other users of oceanographic and atmospheric datasets around the world.

Please provide a summary of the research being conducted.

Research Area	NOAA program supported	Research being conducted and how it relates to NOAA Programs	Geographic Scope	Time frames of research
Fisheries Oceanography	Fishery Management, Protected Species Mgmt, Ecosystem Research	Identifies links between environmental conditions and fisheries abundance.	regional: North Pacific and Bering Sea	long-term
Hydrothermal Vents	Undersea Research and Exploration, Ecosystem Research	Explores new ecosystems associated with undersea volcanoes to identify useful resources.	global: oceanic areas of seafloor volcanism, with regional focus in NE Pacific and other areas in support of other partnerships	long-term
ENSO research	Climate Observations and Analysis	Data collection and analysis that improves seasonal forecasts.	regional: tropical Pacific and Atlantic	long-term
Global Carbon Cycle	Climate Observations and Analysis Climate Forcing	Data collection and analysis that defines oceanic uptakes of CO2 for climate forecasts.	global oceans	long-term
Atmospheric Chemistry	Climate Observations and Analysis Climate Forcing	Data collection and analysis that describes the impact of marine aerosols on climate forecasts.	global oceans, but with regional foci	long-term
Repeat Hydrography	Climate Observations and Analysis Climate Forcing	Data collection and analysis that describes the amount of CO2 in the oceans for climate forecasts.	global oceans	long-term
ARGO floats	Climate Observations and Analysis	Data collection and analysis describes deep ocean circulation for climate forecasts.	global oceans	long-term
Arctic climate	Climate Observations and Analysis	Data collection and analysis to identify climate signals for forecasting Arctic climate.	regional: Arctic region	long-term
Thermal Modeling and Analysis Program	Climate Observations and Analysis	Analysis of seasonal forecast models to determine their skill level and recommend areas of improvement.	global oceans	long-term
Tsunami modeling	Weather & Water Science & Technology Infusion	To develop real time tsunami forecasting capability for NOAA.	regional: Pacific coastal areas	long-term
Tsunami inundation	Weather & Water Science & Technology	To develop long-term tsunami impact assessments for use as planning tools for		

Please provide a listing of 3 – 5 major accomplishments in the last 5 years.

Pacific Marine Environmental Laboratory Accomplishments

A. Near real-time in-situ ENSO Observing. The completion of the Tropical Atmosphere Ocean (TAO) Array in 1994 marked a major milestone in the field of climate observation. The array was designed for monitoring, describing, and predicting El Niño and La Niña events and was implemented through a multi-national effort led by PMEL. It was fully in place to capture the El Niños of 1997-98 (the largest of the 20th century) and 2002-03, providing advance warning of impending global impacts of this climate disturbance.

The TAO Array serves NOAA's operational need to support ENSO forecasts while simultaneously providing research-quality datasets to the scientific community for the purpose of understanding the ocean's role in climate, particularly as it relates to improving ENSO predictions. Researchers and operational forecast centers worldwide are able to access TAO data on a routine basis through the Global Telecommunications System and the World Wide Web. Significant advances have been made in the prediction of ENSO events owing in large part to the free and open availability of these data. Overall, the 1997-1998 El Niño is estimated to have had a total U.S. economic impact of \$25 billion, which emphasizes the benefits of improved predictions of these events.

The TAO Array consists of deep-ocean moorings at 70 locations across the Pacific, with 15 sites in the western Pacific now maintained by the Japan Marine Science and Technology Center (JAMSTEC). Real-time data return has typically been over 80% and, since completion, TAO data have supported 30 to 50 publications per year in the refereed scientific literature. Dr. Michael McPhaden, TAO Project Director, was awarded the NOAA Gold Medal in 1997 for his efforts in completing the Array. In 2003, TAO was awarded a Grace Hopper Government Technology Award ("Gracie Award") for "leadership in the innovative application of information technology that contributes to the advancement of scientific knowledge and its application."

B. FOCI Develops Portable Ocean Observing System to Address NOAA Strategic Goals

Fisheries-Oceanography Coordinated Investigations (FOCI) has developed a portable ocean observing system to aid ecosystem research in the North Pacific Ocean, Gulf of Alaska and Bering Sea. Data collected from these systems improves our understanding of relationships between physical forcing (on varying temporal and spatial scales) and marine productivity. FOCI contributes to NOAA's strategic goals of Fisheries Management and Protected Species Management in the Ecosystem Mission Goal and to the Climate and Ecosystems goal of the Climate Mission Goal.

FOCI's observing system consists of standard and cutting-edge instrumentation to measure the atmospheric, oceanic, and biological marine environment. Sophisticated biophysical moorings employing acoustic Doppler current meters, nutrient meters, bioacoustics to measure zooplankton, and phytoplankton samplers are coupled with satellite-tracked drifters, and ship-based hydrographic and biological surveys to create a dynamic observing system that is tuned to meet fisheries management goals and answer specific scientific questions. Ancillary platforms, such as aircraft, remotely operated and towed vehicles, and ARGO floats, are incorporated, as needed, to meet special observing needs.

FOCI makes annual forecasts of walleye pollock abundance to support the management responsibilities of the North Pacific Fishery Management Council. Pollock is by far the largest component of the lucrative Alaska groundfish industry, which comprises 47% of the entire U.S. fish catch by weight. Technological upgrades to the observing system are allowing FOCI to improve its forecasting ability and extend it to a more ecosystem-wide assessment. FOCI's observing system has also enabled determination of important relationships between high latitude climate patterns and the changing ecosystem of the Bering Sea, the physical environment and the health of endangered Steller sea lions, and identified pulse points that control dynamical processes along the Gulf of Alaska shelf. In addition to supporting fisheries management decisions, FOCI researchers have published more than 300 articles in the peer-reviewed literature in support of fisheries management and ecosystem research. The joint NMFS/OAR team that comprises the FOCI Program was awarded a joint organizational Bronze Medal in 2002 in recognition of their contributions to fisheries management.

Besides supporting FOCI research, the portable observing system will be an important addition to the Alaska Ocean Observing System (AOOS) and the Integrated Ocean Observing System (IOOS) of the United States. In this way, FOCI is able to provide additional benefit beyond its operational objectives supporting NOAA's strategic plan.

C. NeMO: A Portable Long-Term Deep Ocean Seafloor Observatory

While it is now known that deep ocean volcanism and hydrothermal venting play important roles in the dynamic states of the ocean's physical, chemical, and biological environments, quantitative description of the impacts of these global processes is currently unknown. Seafloor observatories have become the means to begin to develop and deploy innovative sensors to acquire the time series data that will enable ocean scientists to understand how the Earth's largest volcanic system affects both the global ocean and its interactions with the atmosphere and life on land. NeMO, the New Millennium Observatory, is a pioneering effort by NOAA to begin addressing these issues. NeMO has been established within the caldera of an active volcano which lies nearly one mile beneath the ocean's surface. At NeMO, NOAA oceanographers are conducting continuous, *in situ* experiments that monitor the changing conditions on the seafloor and in the overlying water column. Experiments include ocean current movements, sampling and culturing unique microorganisms that are jetted out of the seafloor in volcanically driven hot springs (vents), measurements of the influx of

volcanic and hydrothermal heat and of volcanically-derived chemical nutrients, sensing of movements of the seafloor that presage the movement of magma within the active volcano, and geophysical measurements of actual eruptions. All of these experiments are resulting in discoveries that are revealing how deep ocean volcanic and hydrothermal activity have important impacts on both deep and upper ocean ecosystems. The experiments are also revealing the presence of new potential living and non-living exploitable resources.

NeMO is a first in the world of ocean exploration for a number of reasons, including that it is the embodiment of the first long-term commitment to understanding deep ocean volcanic activity. NeMO is unique in that it is the world's only portable deep ocean seafloor observatory with two-way, real-time communication links. The system that makes this possible was developed by PMEL's Vents program and is called NeMO Net. A visit to the NeMO Net website

<http://www.pmel.noaa.gov/vents/nemo/realtime/index.html>) enables an observer to know the temperatures at, and near, an active hydrothermal vent. Other sensors include a suite of chemical detectors, a seafloor tectonic motion detector, and a sampling system that routinely takes water samples for later biological and chemical analyses. NeMO Net was specially designed to operate within a very dynamic environment---i.e., an active high-temperature hydrothermal vent in the caldera of an active volcano. To that end, NeMO employs technology that enables a shore-based scientist to interact with the seafloor sensors by means of sending them commands from the NeMO Net website. This means that NeMO Net can be commanded to respond to ephemeral events on the seafloor, including volcanic eruptions. NeMO Net is a prototype observatory that is undergoing continuing refinement and enhancement of its capabilities. Current plans are to equip NeMO Net with a commandable Autonomous Undersea Vehicle that will remain parked within the volcano's caldera and will be able to conduct survey and sampling missions on command and then report results back to observers on shore. Because it is a mooring-based observatory, NeMO Net is highly portable, a very practical aspect because our knowledge of underwater volcanoes is so primitive that selecting a single location may prove risky.

D. Development of the first portable tsunameter which provides data necessary to forecast tsunamis in real time. Also known as "DART" moorings, the tsunameter was developed by PMEL to increase warning time and the accuracy of tsunami warnings. Prior to the development of the tsunameter, tsunami warnings were based on historical data and data from coastal water level gauges. PMEL-developed tsunameter technology quantifies tsunami energy rather than energy inferred indirectly from earthquake data. Since tsunami formation is composed of earthquake and simultaneous landslide energy, tsunameters provide the only data that can lead to a tsunami forecast. Because the buoy-based tsunameters are portable, the position of tsunameters can be adjusted as we learn more about tsunamis. Ongoing research and development for NOAA's tsunami warning centers has created an experimental tsunami wave forecast capability. The utility of the system was demonstrated on November 17, 2003, when a small tsunami, generated by an Alaskan earthquake, was detected by the nearest tsunameter. The tsunameter relayed data

in real time to the NOAA Tsunami Warning Centers. These data were used to cancel a tsunami warning which had been issued earlier, thereby avoiding the coastal evacuation of Hawaii – saving \$68M in lost productivity. These data were also used to accurately forecast, in real time, the tsunami impact in Hilo Bay, Hawaii. In 2001, PMEL initiated the transfer of responsibility for the Pacific-wide tsunameter array to the National Data Buoy Center. The transition was completed at the end of FY2003. The DART/tsunameter technology is to be highlighted in a 2004 Special Issue of the publication “Natural Hazards.”

In parallel with the tsunameter development efforts, PMEL, working in cooperation with the five Pacific states, FEMA, and the USGS through the National Tsunami Hazard Mitigation Program, has been instrumental in the leadership of the development of tsunami inundation maps for at-risk coastal communities. These maps provide emergency managers and community planners with information they need to guide community development and preparedness activities. To date, maps have been produced for 122 communities protecting 1.3 million coastal residents. The goal of the entire tsunami program at PMEL is to provide more accurate NOAA tsunami warnings of tsunami coastal impacts and provide at-risk communities with tools they need to better plan for the next tsunami.

PMEL’s leadership in developing and implementing the National Tsunami Hazard Mitigation Plan (NTHMP) was recognized through a Presidential Rank Award for Dr. Eddie Bernard, the first Chair of the NTHMP Steering Group.

Please provide a summary of legal mandates for the work in the laboratory/center.

Major legal mandates, policy statements, and treaties that serve as drivers for PMEL’s research activities:

Legislation:

National Materials and Minerals Policy Research and Development Act (PL 96-479)
Magnuson-Stevens Fishery Conservation and Management Act (PL 94-265, as amended)
Deep Seabed Hard Mineral Resources Act of 1980 (30 U.S.C. 1419)
Methane Hydrate Research and Development Act of 2000 (30 USC 1902)
Marine Mammal Protection Act of 1972 (16 U.S.C. 1361 et seq.)
Global Change Research Act of 1990 (15 USC 2921 et seq.)

Policy:

President’s Ocean Exploration Panel report: “Discovering the Earth’s Final Frontier: A US Strategy for Ocean Exploration”, 2000.
National Research Council Report “Marine Biotechnology in the Twenty-First Century: Problems, Promise, and Products” , 2002.
U.S. Climate Change Science Plan Strategic Plan, 2003

International Policy:

GCOS Second Adequacy Report to the UNFCCC

Treaty:

PICES (North Pacific Marine Science Organization), ratified December 6, 1991

Memorandum of Understanding

With the Japan Marine Science and Technology Center (JAMSTEC) for Collaboration in Research, signed December 15, 2002.

6. Attach in Excel format the compilation of financial and staffing data that your laboratory or line office provided.

FY 2003 - PMEL Obligations

Perm Base	Other NOAA	Non-NOAA	Pass Through	Total
\$9.02KK	\$13.51KK	\$1.57KK	\$10.51KK	\$34.61KK

Note:

Obligations include only those costs/obligations incurred directly against PMEL accounting (50-27-0000-00-00-00-00)

Perm Base - Does not include FOCI/NMFS; does not include NTHMP

Other NOAA - does not include NOAA Corporate Costs, etc.

FY 2003 - PMEL Staff

Federal	Contractors	JI	Others	Total
85	21	68	0	174